

Coal Mine Methane Recovery & Utilization in the United States:



CMOP's Coal Mine Methane Project Cash Flow Model

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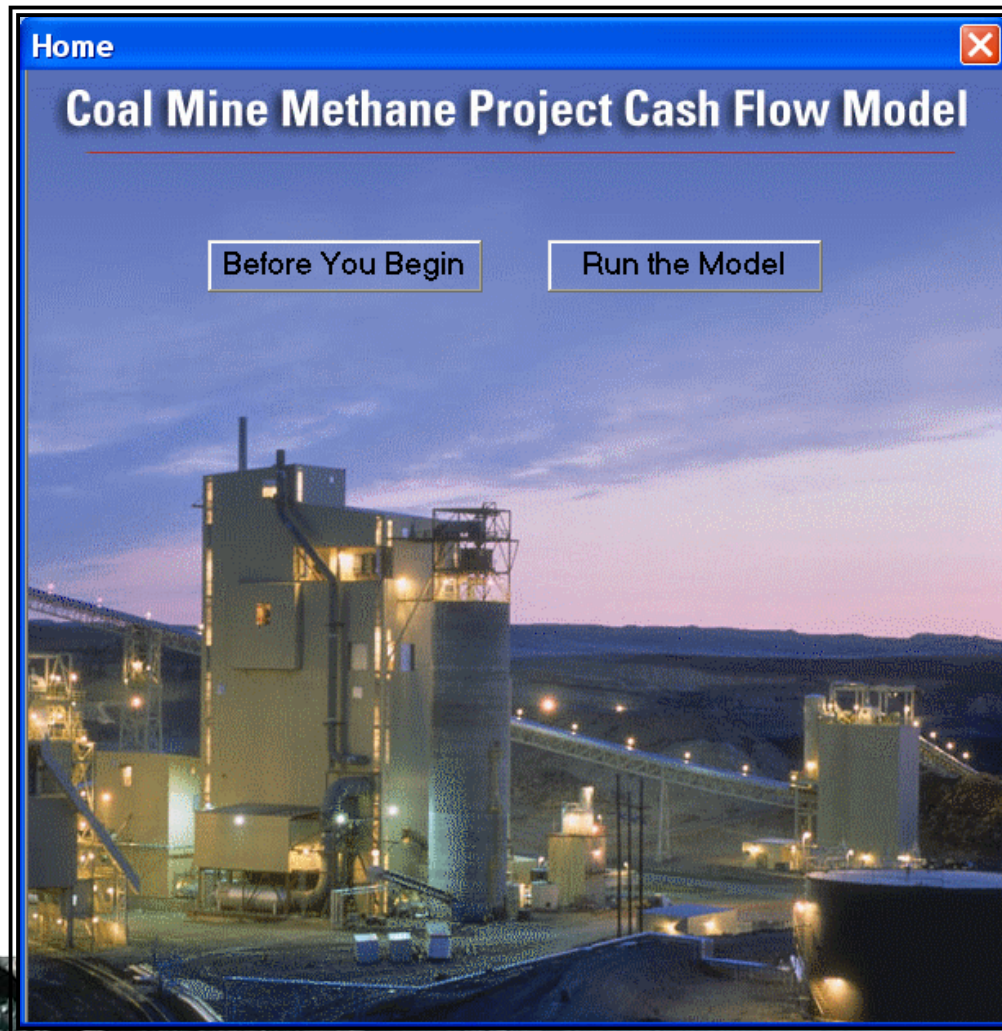


- **CMOP Mission: to work with the coal mining and related industries to reduce CMM emissions **cost-effectively****
- What we do in a nutshell:
 - Identify **profitable** opportunities for project development
 - Identify and help overcome market, regulatory, and technical barriers
 - Offer technical and analytic support where appropriate
 - Conduct direct outreach to coal mines
- **Need for a tool to analyze CMM project costs and benefits**

- **Coal Mine Methane Project Cash Flow Model**

- Goal: user-friendly, attractive, informative, and useful
- Assembled a team of economists, programmers, and CMM industry specialists with on-the-ground experience
- Carefully selected six end-uses for U.S. market
- Surveyed external industry experts for specific default and recommended parameters
- Conducted internal and third-party review to ensure operability and accuracy

- Coal Mine Methane Project Cash Flow Model *Beta Version*



- **Model is designed to:**

- Provide first-cut estimate of CMM project economics
- Compare profitability of different end use options at a particular site
- Help project developers and equipment vendors better understand their customers

- **Model is NOT designed to:**

- Replace detailed economic analysis or feasibility study
- Replace an in-house, site specific model

- Choose an end-use

Start

Coal Mine Methane Project Cash Flow Model

Go Back

1. Select a methane end use scenario for cash flow analysis:

☐ Coal Drying

☐ Flaring - Enclosed

☐ Flaring - Open

☐ Mine Boilers

☐ On-site Electricity Generation - Engine

☒ Pipeline Gas

Scenario Help

2. What percent methane is the drained gas? % [Minimum: 40%]

Continue

Provide four (4) categories of inputs

Gas Collection

- Gathering and Delivery System Parameters
- Drainage Well Development Costs

Pipeline Gas

Gas Collection | Gas Availability | User-Defined Inputs | Default Parameters

Gathering & Delivery System Parameters	Amount / Units	Recommended Values
What is the cost of satellite compressors?	1000 \$/HP	[1,000]
What is the distance from the drainage area to the onsite project?	21000 ft	[21,000]
What is the cost of installing header pipe from the drainage area?	40 \$/ft	[40]
What are the compressor and blower efficiencies?	0.035 HP/mcfd	[0.02-0.07]
What is the mining rate?	12000 ft/yr	[12,000]

Do you want to include the drainage well and drainage blower development costs in this cost analysis? ☒ Yes ☐ No

What is the cost of well-head blowers?	1000 \$/HP	[1,000]
What is the spacing between gob wells?	1000 ft	[1,000]
What is the mine depth?	500 ft	[1,000]
What is the drilling cost?	140 \$/ft	[140]
What is the fraction of this project's drainage system cost that will be included in the analysis?	100 %	[100]

Note: The drainage system cost is based on supplying only the portion of available drainage gas that is needed by the project. However, the user can elect to allocate only a percentage of this cost to the project. See the Users Manual for additional information.

<< Back Next >> Calculate Select New Scenario Units Help

- **Gas Collection** – estimating gathering & delivery costs
 - 100% of costs are included – no opt out

1) Gathering system (**G**) annual operating cost inputs:

Mining rate, ft/yr (12,000 ft/yr default)

Unit cost of pipeline installed (40 \$/ft default)

$$\mathbf{G} = 12,000 \text{ ft} \times 40 \$ / \text{ft} = 480,000 \$ / \text{yr}$$

2) Compressor (**C**) capital cost inputs:

Compressor cost, \$/hp (\$1000/hp default)

Compressor efficiency, hp/mcfd (0.035 hp/mcfd default)

Gas flow rate, mcfd (no default)

$$\mathbf{C} = (\$1000/\text{hp}) * (0.035 \text{ hp}/\text{mcfd}) * (x \text{ mcfd})$$

- **Gas Collection** – estimating gathering & delivery costs
cont.

3) Pipeline (**P**) capital cost inputs:

Pipe cost, \$/ft (\$40/ft default)

Pipeline length, ft (21,000 ft default)

$$P = (\$40/\text{ft}) * (21,000 \text{ ft}) = \$840,000$$

- **Gas Collection** – estimating drainage development costs
 - Default is to exclude these costs from the analysis
 - User can decide to include a fraction of these costs

1) Gob well (**W**) annual operating cost inputs:

Well spacing, ft/well	(1,000 ft/well default)
Mining rate, ft/yr	(12,000 ft/yr default)
Mine depth, ft	(1,000 ft default)
Unit drilling cost, \$/ft	(140 \$/ft default)

$$W = \frac{12,000 \text{ ft} / \text{yr}}{1,000 \text{ ft} / \text{well}} \times 1,000 \text{ wells} \times 140 \$ / \text{ft} = 1,680,000 \$ / \text{yr}$$

*Selecting the default mining rate of 12,000 ft/yr and the default well spacing of 1,000 ft/well results in a model-assumed well installation rate of 12 wells per year.

- **Gas Collection** – estimating gathering & delivery costs cont.

2) Blower (**B**) capital cost inputs:

Blower cost, \$/hp	(\$1000/hp default)
Blower efficiency, hp/mcfd	(0.035 hp/mcfd default)
Gas flow rate, mcfd	(no default)

$$\mathbf{B} = (\$1000/\text{hp}) * (0.035 \text{ hp}/\text{mcfd}) * (x \text{ mcfd})$$

3) **F** = the fraction of the drainage system cost that is included in the CMM project cost.

- **Gas Collection - summary**

- Annual operating cost = $G + (W * F)$

- Capital Cost = $C + P + (B * F)$

- F is applied only to drainage development costs
- B and W can be excluded by defining F as 0
- B and W can be partially borne by the CMM project bottom line and partially by the coal production bottom line
- Assume that B and C are powered by the project CMM

- Provide four (4) categories of inputs

2. Gas Availability

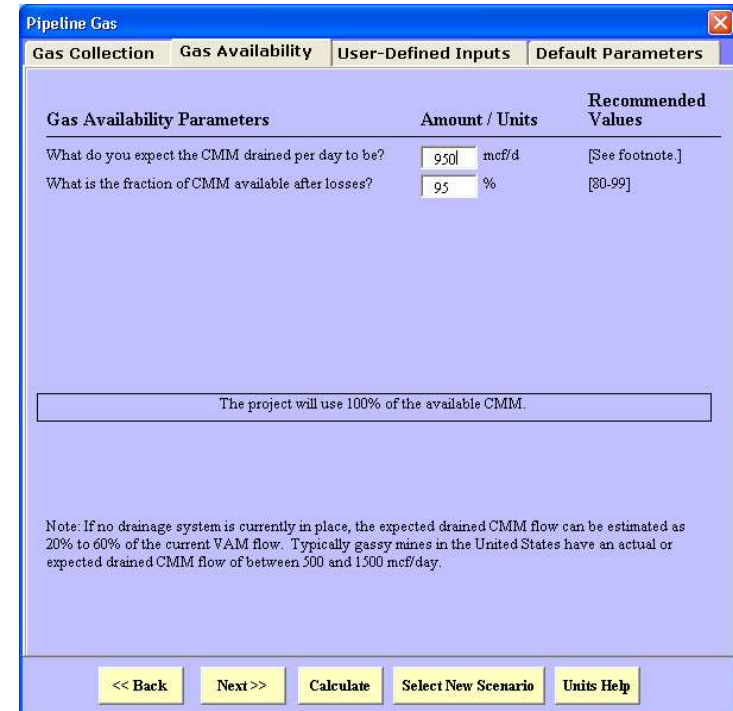
- CMM drained per day
- Some requested inputs are end-use specific

3. User-Defined Inputs

- Create a Scenario Name
- Input site-specific parameters such as distances, prices, equity structure

4. Default Parameters

- Input parameters that are independent of the project such as inflation; royalty, severance tax, and negotiation fees; contingency factor.



The screenshot shows the 'Pipeline Gas' software window with the 'Gas Availability' tab selected. The window has four tabs: 'Gas Collection', 'Gas Availability', 'User-Defined Inputs', and 'Default Parameters'. The 'Gas Availability' tab contains a table with the following data:

Gas Availability Parameters	Amount / Units	Recommended Values
What do you expect the CMM drained per day to be?	950 mcf/d	[See footnote.]
What is the fraction of CMM available after losses?	95 %	[80-99]

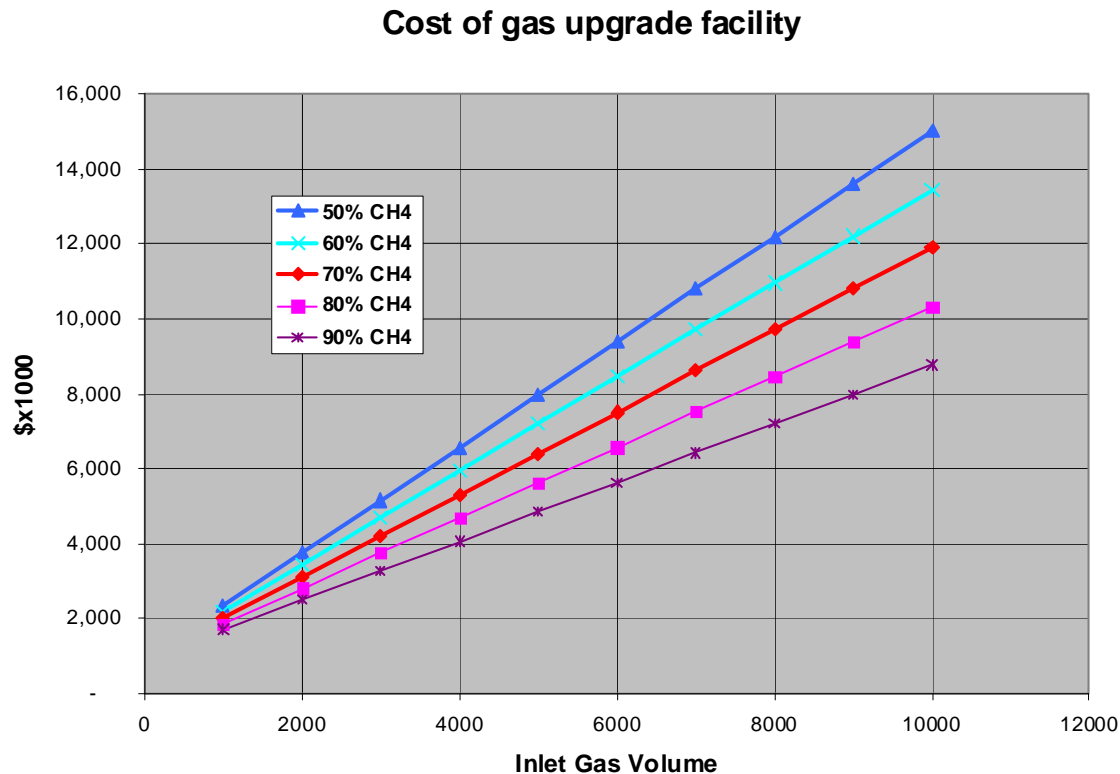
Below the table, a text box states: 'The project will use 100% of the available CMM.'

A note at the bottom reads: 'Note: If no drainage system is currently in place, the expected drained CMM flow can be estimated as 20% to 60% of the current VAM flow. Typically gassy mines in the United States have an actual or expected drained CMM flow of between 500 and 1500 mcf/day.'

At the bottom of the window are five buttons: '<< Back', 'Next >>', 'Calculate', 'Select New Scenario', and 'Units Help'.

- **Model Calculations – Pipeline Injection**

➤ Assume installation of membrane or pressure swing adsorption system to remove nitrogen and CO₂



- **Model Calculations – Coal Dryers and Mine Boilers**
 - Model assumes existing equipment will be retrofit, so capacity remains constant during switch
 - Up to 100% of CMM will offset coal used, and any remaining demand will be met by coal
 - ie: model allows for co-firing
 - Other end-use scenarios assume new equipment is specified for available CMM volumes

- **Model Outputs**

- CMM available for other projects – model can be rerun
- IRR, NPV, CERs earned (tonnes/year), equity and debt requirements
- Some inputs are repeated to inform the final analysis
 - Interest rate, discount rate, carbon credit price
- Can generate an attractive flyer to save or print
 - Cash flow analysis bar graph
- Can return to input screen to modify specific variables and rerun your scenario

- **Summary** – CMOP tool available to help YOU analyze the costs and benefits of implementing a CMM use project
- **Next Steps**
 - visit CMOP booth for model demonstration
 - Get started with the User's Guide
 - Download model from www.epa.gov/cmop
 - Contact CMOP with any question, requests for assistance, or suggestions for enhancement
 - CMOPmodel@erg.com
 - Lynn Somers 202-242-0806

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- **Model Calculations – Pipeline Injection, cont.**
 - Some methane is removed into waste stream, depending on the concentration of methane in the inlet gas

Methane Recovery Efficiency

